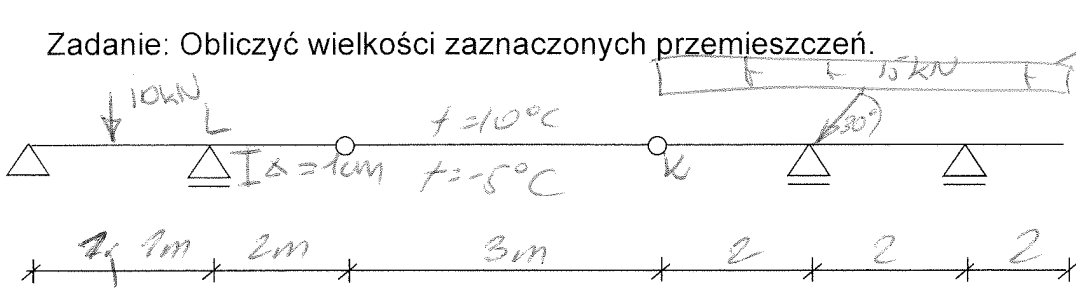


ĆWICZENIE PROJEKTOWE Z MECHANIKI BUDOWLI nr 2

Zadanie: Obliczyć wielkości zaznaczonych przemieszczeń.

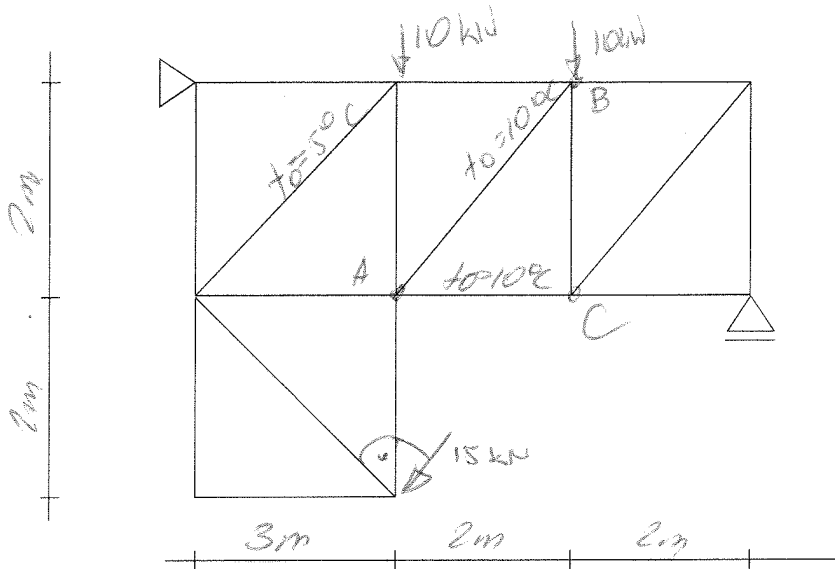


Przekrój: I 450

$E = 2.1 \cdot 10^5 \text{ MPa}$

$\alpha_t = 1.2 \cdot 10^{-5} \text{ 1/K}$

$\Delta \varphi_k$
 $\Delta \varphi_L$

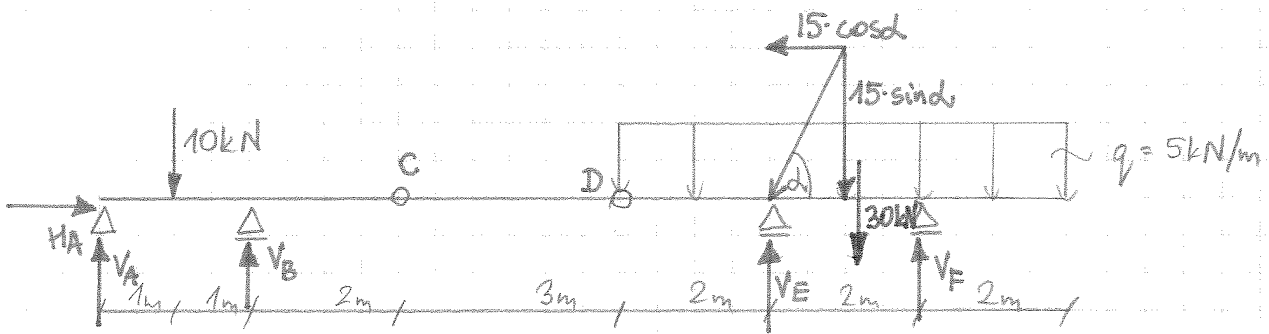


Przekrój: L 80x80x8

$E = 2.1 \cdot 10^5 \text{ MPa}$

$\alpha_t = 1.2 \cdot 10^{-5} \text{ 1/K}$

ΔL_{A-B}
 Δy_C



STAN "P"

$$n = Lr - (3 + p)$$

$$n = 5 - (3 + 2)$$

$n = 0 \Rightarrow$ układ statycznie sprężysty

$$\sin 30^\circ = 0,5$$

$$\cos 30^\circ = 0,86$$

$$\sum M_C^{\ominus} = 0$$

$$\left. \begin{array}{l} V_A \cdot 4 + V_B \cdot 2 - 10 \cdot 3 = 0 \\ V_A + V_B - 10 = 0 \end{array} \right\} \quad \underline{V_A = 5 \text{ kN}}$$

$$\underline{V_B = 5 \text{ kN}}$$

$$\sum X = 0$$

$$H_A - 15 \cdot \cos 30^\circ = 0$$

$$\underline{H_A = 12,9 \text{ kN}}$$

$$\sum M_D^{\oplus} = 0$$

$$\left. \begin{array}{l} -V_E \cdot 2 + 15 \cdot \sin 30^\circ \cdot 2 + 30 \cdot \frac{1}{2} \cdot 6 - V_F \cdot 4 = 0 \\ V_C + V_D - 15 \cdot \sin 30^\circ - 30 = 0 \end{array} \right\} \quad \underline{V_E = 22,5 \text{ kN}}$$

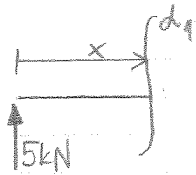
$$\underline{V_F = 15 \text{ kN}}$$

sprężystość

$$\sum M_A = 10 - 5 \cdot 2 - 22,5 \cdot 9 + 30(3+7) - 15 \cdot 11 + 15 \cdot 0,5 \cdot 9 = 0$$

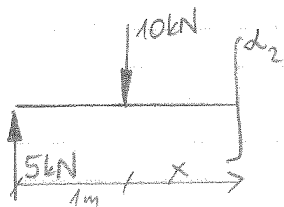
Sily i momenty w przekrojach (momenty)

$d_1 - d_1 \quad x \in (0, 1)$



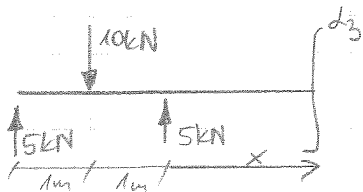
$$M_1 = 5 \cdot x \quad \begin{matrix} M_1(0) = 0 \\ M_1(1) = 5 \text{ kNm} \end{matrix}$$

$d_2 - d_2 \quad x \in (0, 1)$



$$M_2 = 5(1+x) - 10x \quad \begin{matrix} M_2(0) = 5 \text{ kNm} \\ M_2(1) = 0 \end{matrix}$$

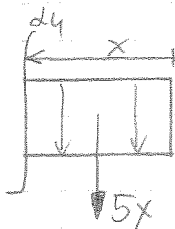
$d_3 - d_3 \quad x \in (0, 2)$



$$M_3 = 5(2+x) + 5x - 10(1+x)$$

$$\begin{matrix} M_3(0) = 0 \\ M_3(2) = 0 \end{matrix}$$

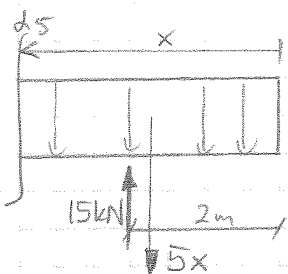
$d_4 - d_4 \quad x \in (0, 2)$



$$M_4 = -5x \cdot \frac{1}{2}x = -\frac{5}{2}x^2$$

$$\begin{matrix} M_4(0) = 0 \\ M_4(2) = -10 \text{ kNm} \end{matrix}$$

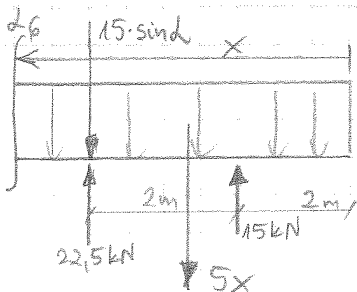
$d_5 - d_5 \quad x \in (2, 4)$



$$M_5 = -5x \cdot \frac{1}{2}x + 15(x-2)$$

$$\begin{matrix} M_5(2) = -10 \text{ kNm} \\ M_5(4) = -10 \text{ kNm} \end{matrix}$$

$d_6 - d_6 \quad x \in (4, 6)$



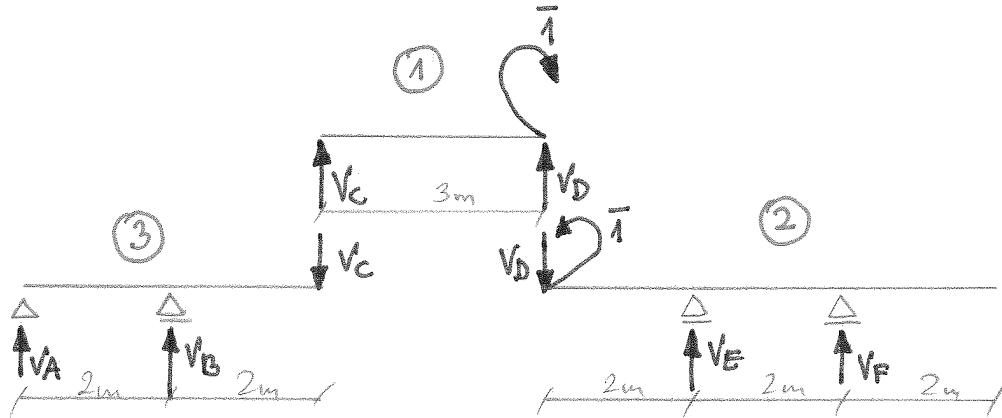
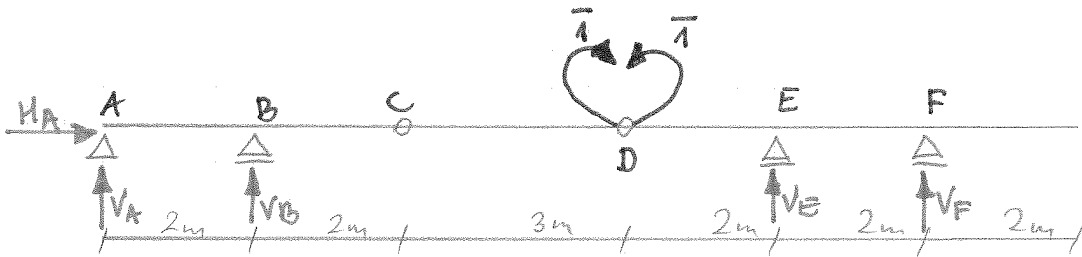
$$M_6 = -15 \sin(x-4) - 5x \cdot \frac{1}{2}x + 22,5(x-4) + 15(x-2)$$

$$\begin{matrix} M_6(4) = -10 \text{ kNm} \\ M_6(6) = 0 \end{matrix}$$

Kąt obrotu przeszerzenia w punkcie D

$$\Delta \varphi_D$$

STAN "i"



$$\sum X = 0 \quad \underline{H_A = 0}$$

$$\begin{aligned} \textcircled{1} \quad \sum M_C = 0 \\ -V_D \cdot 3 + 1 = 0 \\ -V_D \cdot 3 = -1 \\ \underline{V_D = \frac{1}{3}} \end{aligned}$$

$$\begin{aligned} \sum Y = 0 \\ V_C + V_D = 0 \\ \underline{V_C = -\frac{1}{3}} \end{aligned}$$

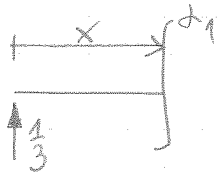
$$\begin{aligned} \textcircled{2} \quad \sum M_F = 0 \\ V_E \cdot 2 - 4V_D - 1 = 0 \\ V_E \cdot 2 = \frac{4}{3} + 1 \\ \underline{V_E = \frac{7}{6}} \end{aligned}$$

$$\begin{aligned} \sum Y = 0 \\ -V_D + V_E + V_F = 0 \\ V_F = V_D - V_E \\ \underline{V_F = -\frac{5}{6}} \end{aligned}$$

$$\begin{aligned} \textcircled{3} \quad \sum M_A = 0 \\ -V_B \cdot 2 - \frac{1}{3} \cdot 4 = 0 \\ \underline{V_B = -\frac{2}{3}} \end{aligned}$$

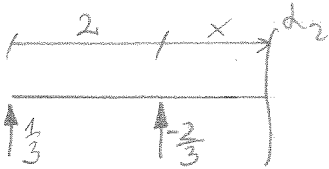
$$\begin{aligned} \sum Y = 0 \\ V_A + V_B - V_C = 0 \\ V_A = -V_B + V_C \\ \underline{V_A = \frac{1}{3}} \end{aligned}$$

Sily osiowe w przekrojach (momenty)



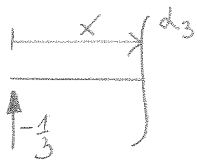
$$d_1 - d_1 \quad x \in (0, 2)$$

$$M_1 = \frac{1}{3} \cdot x \quad \begin{matrix} M_1(0) = 0 \\ M_1(2) = \frac{2}{3} \end{matrix}$$



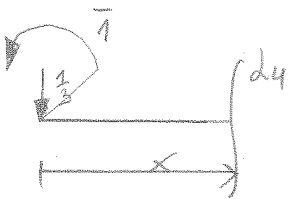
$$d_2 - d_2 \quad x \in (0, 2)$$

$$M_2 = \frac{1}{3}(2+x) - \frac{2}{3}x \quad \begin{matrix} M_2(0) = \frac{2}{3} \\ M_2(2) = 0 \end{matrix}$$



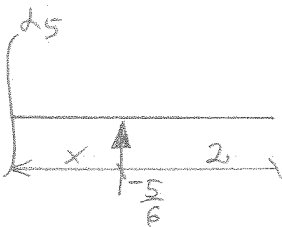
$$d_3 - d_3 \quad x \in (0, 3)$$

$$M_3 = -\frac{1}{3}x \quad \begin{matrix} M_3(0) = 0 \\ M_3(3) = -1 \end{matrix}$$



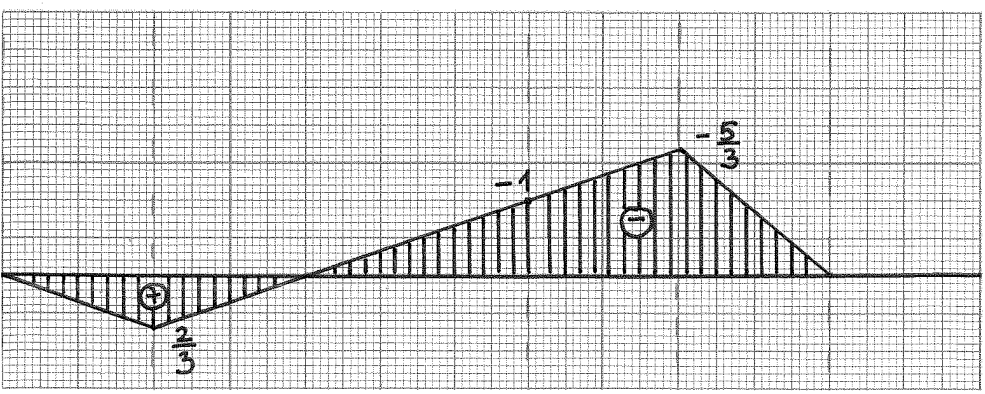
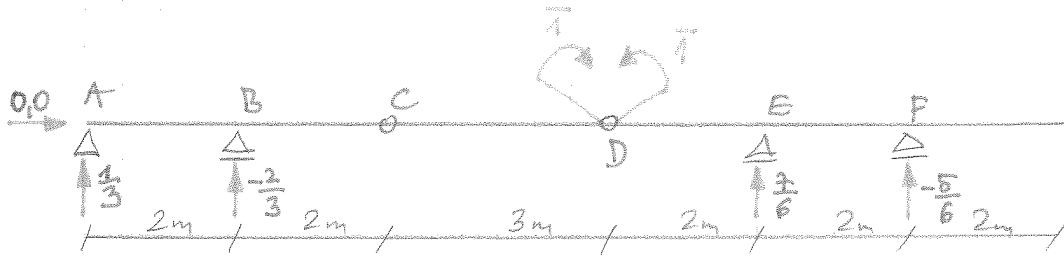
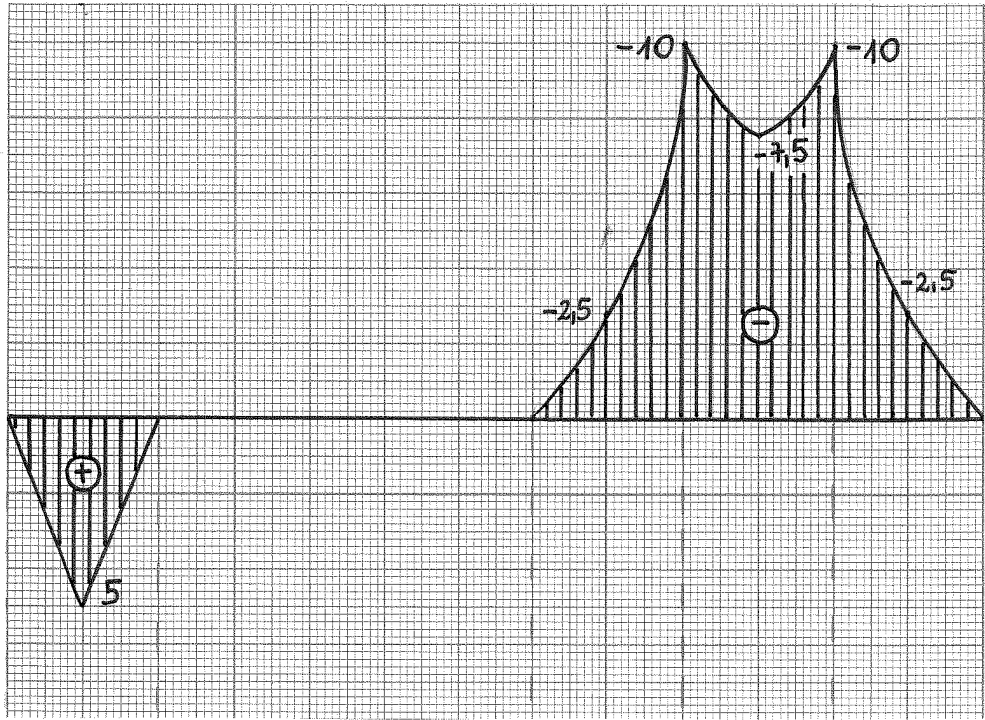
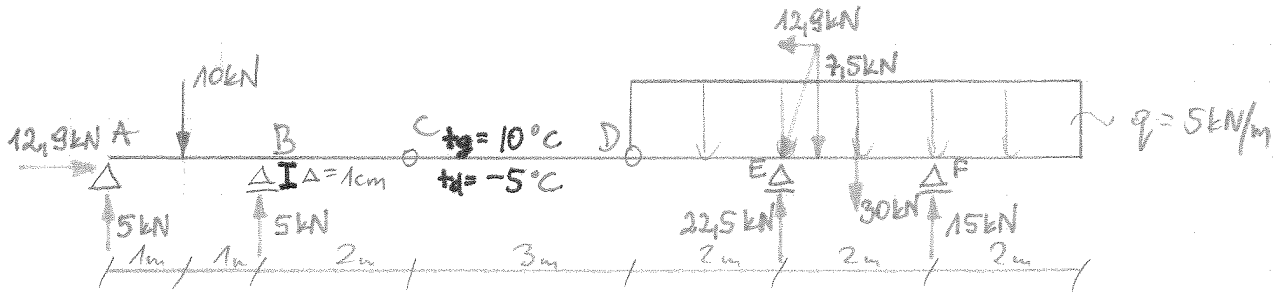
$$d_4 - d_4 \quad x \in (0, 2)$$

$$M_4 = -1 - \frac{1}{3}x \quad \begin{matrix} M_4(0) = -1 \\ M_4(2) = -\frac{5}{3} \end{matrix}$$



$$d_5 - d_5 \quad x \in (0, 2)$$

$$M_5 = -\frac{5}{6}x \quad \begin{matrix} M_5(0) = 0 \\ M_5(2) = -\frac{5}{3} \end{matrix}$$

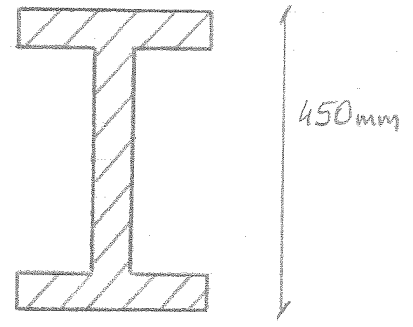


M_p
 M_i

$$\bar{1} \cdot \psi_D = \sum_n \int_S \frac{M_D \cdot \bar{M}_i}{EJ} \cdot dS + \sum_n \int_S \frac{\bar{M}_i \cdot \Delta t \cdot dt}{h} \cdot dS + \sum_n \int_S \bar{N}_i \cdot dt \cdot to \cdot dS$$

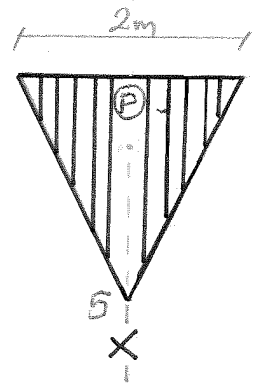
$$- \sum_n \bar{R}_i \cdot \Delta$$

Przekrój pręta



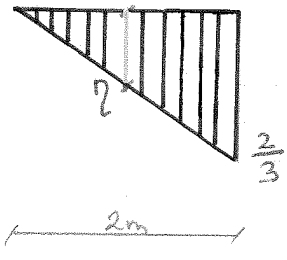
$$W_{ip}^N = \sum_n \int_S \frac{M_D \cdot \bar{M}_i}{EJ} \cdot dS = \frac{A + B + C}{EJ}$$

(A)

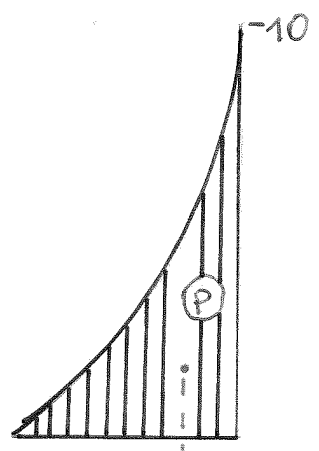


$$\eta = \frac{1}{3}$$

$$A = P \cdot \eta = \frac{1}{2} \cdot 2 \cdot 5 \cdot \frac{1}{3} = 1,667 \text{ kNm}^2$$

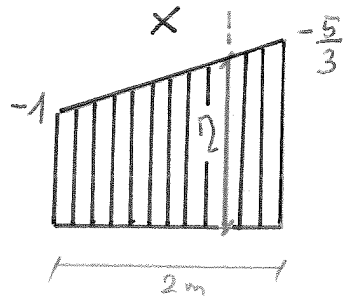


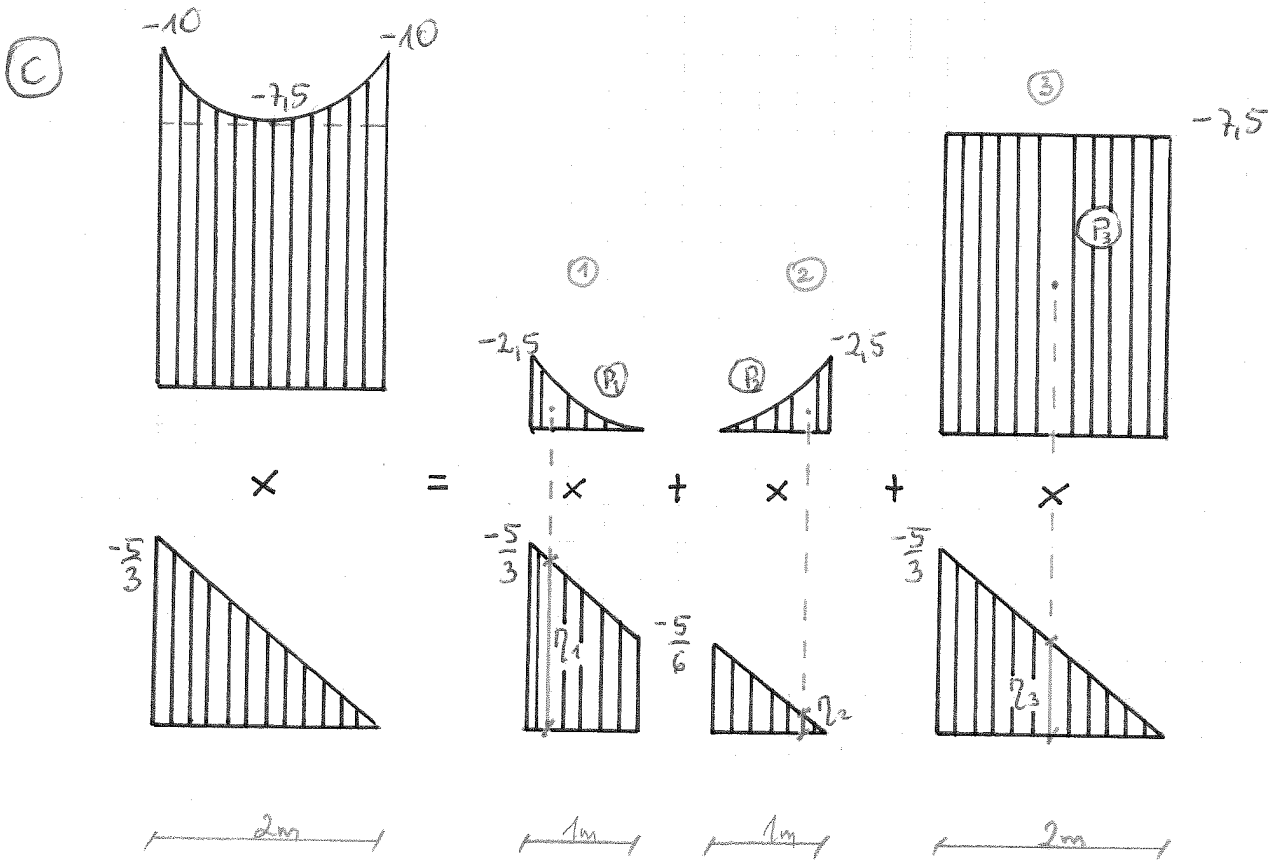
(B)



$$\eta = -\frac{3}{2}$$

$$B = P \cdot \eta = \frac{1}{3} \cdot 2 \cdot (-10) \cdot \left(-\frac{3}{2}\right) = 10 \text{ kNm}^2$$





$$\begin{cases}
 \textcircled{1} P_1 \cdot \eta_1 = \frac{1}{3} \cdot 1 \cdot \left(-\frac{5}{2}\right) \cdot \left(-\frac{35}{24}\right) = \frac{175}{144} = 1,215 \text{ kNm}^2 \\
 \textcircled{2} P_2 \cdot \eta_2 = \frac{1}{3} \cdot 1 \cdot \left(-\frac{5}{2}\right) \cdot \left(-\frac{5}{24}\right) = \frac{25}{144} = 0,174 \text{ kNm}^2 \\
 \textcircled{3} P_3 \cdot \eta_3 = -7,5 \cdot 2 \cdot \left(-\frac{5}{6}\right) = 12,5 \text{ kNm}^2
 \end{cases}$$

$$C = 13,889 \text{ kNm}^2$$

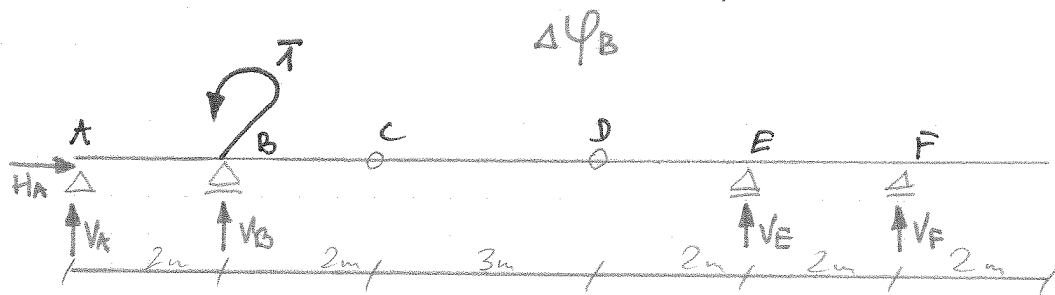
$$td - ty = -5 - 10 = -15$$

$$\bar{1} \cdot \psi_D = \frac{1,667 \text{ kNm}^2 + 10 \text{ kNm}^2 + 13,889 \text{ kNm}^2}{2,1 \cdot 10^8 \frac{\text{kN}}{\text{m}^2} \cdot 45850 \cdot 10^{-8} \text{ m}^4} + \frac{\frac{1}{2} \cdot 3 \text{ m} \cdot (-1) \cdot (-15 \text{ K})}{0,45 \text{ m}} \cdot 2,1 \cdot 10^{-5} \text{ 1/K} + 0$$

$$- \left(\frac{2}{3 \text{ m}}\right) \cdot 0,01 \text{ m}$$

$$\bar{1} \cdot \psi_D = -0,00296 \text{ [rad]}$$

Kąt obrotu przemieszczenia w punkcie B



$$\sum X = 0 \quad H_A = 0$$

STAN "i"

$$\left\{ \begin{array}{l} \sum M_C^L = 0 \quad V_B \cdot 2 + V_A \cdot 4 - 1 = 0 \\ \sum Y = 0 \quad V_A + V_B = 0 \quad V_A = -V_B \end{array} \right.$$

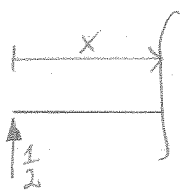
$$V_B \cdot 2 - V_B \cdot 4 = 1$$

$$\underline{V_B = -\frac{1}{2}} \quad \underline{V_A = \frac{1}{2}}$$

$$\left\{ \begin{array}{l} \sum M_D^P = 0 \quad -V_E \cdot 2 - V_F \cdot 4 = 0 \\ \sum Y = 0 \quad V_E + V_F = 0 \end{array} \right.$$

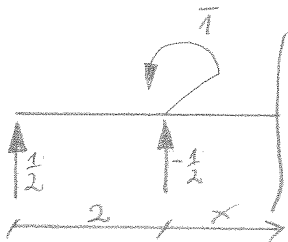
$$\underline{V_E = 0} \quad \underline{V_F = 0}$$

Sily wewnętrzne w przekrojach (momenty)



$$d_1 - d_1 \quad x \in (0, 2)$$

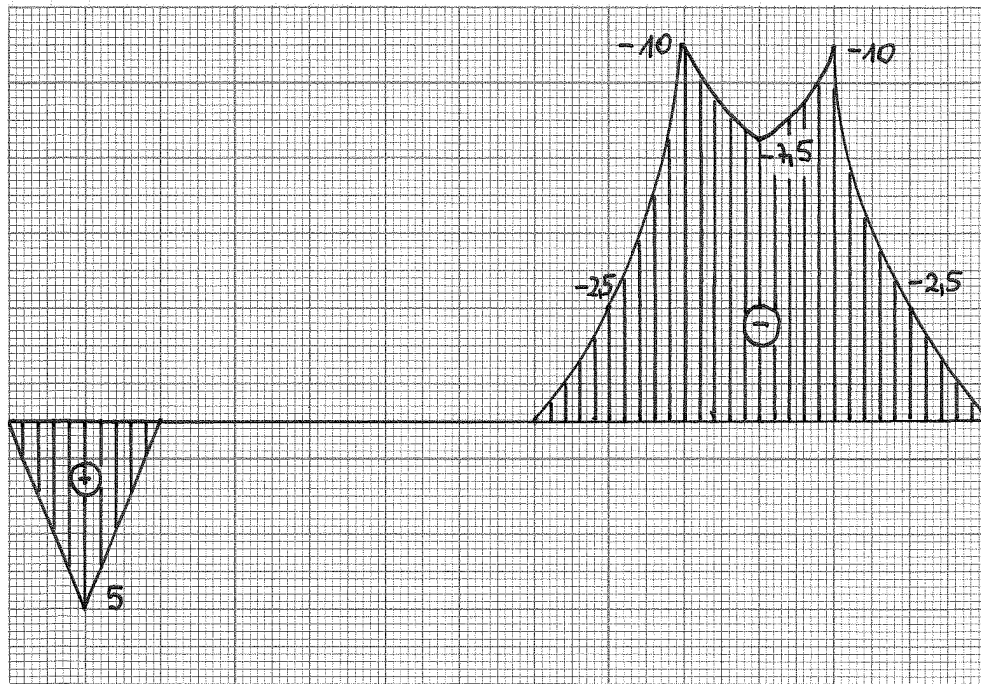
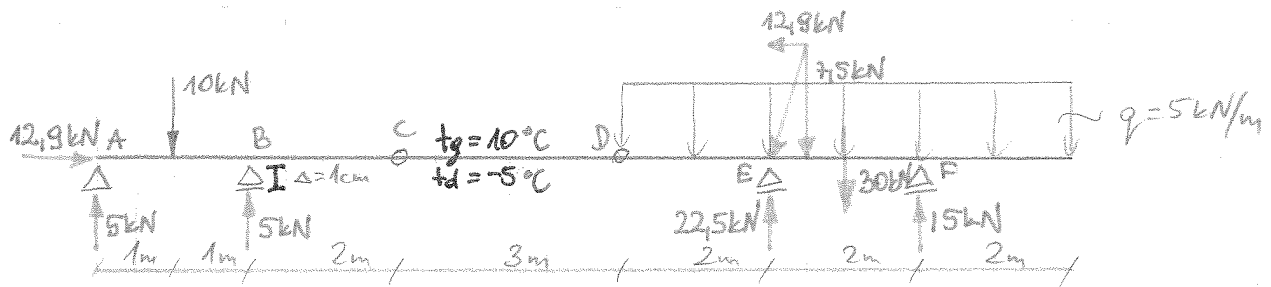
$$M_1 = \frac{1}{2}x \quad \left. \begin{array}{l} M_1(0) = 0 \\ M_1(2) = 1 \end{array} \right\}$$



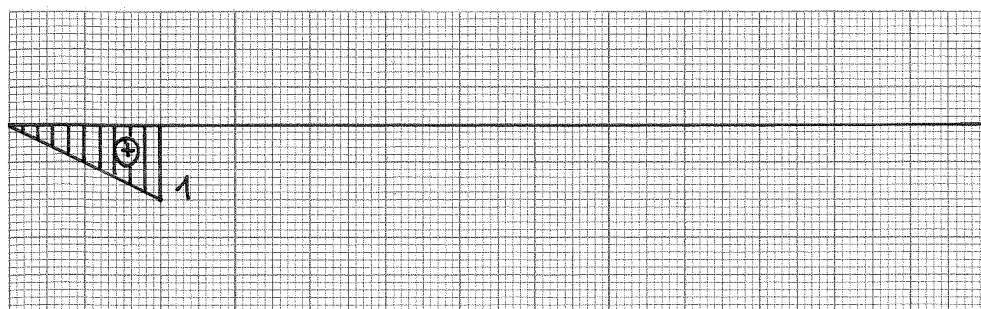
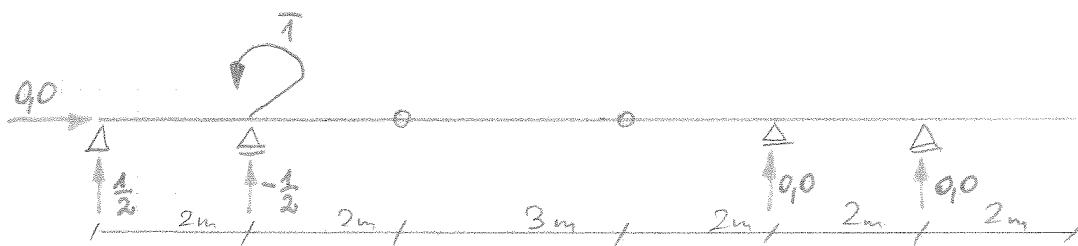
$$d_2 - d_2 \quad x \in (0, 2)$$

$$M_2 = -\frac{1}{2}x - 1 + \frac{1}{2}(2+x)$$

$$\left. \begin{array}{l} M_2(0) = 0 \\ M_2(2) = 0 \end{array} \right\}$$



M_p



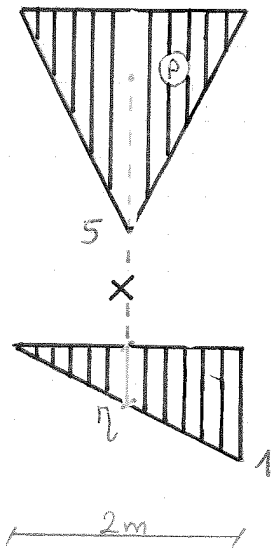
" Ψ_B "

M_i

$$\bar{1} \cdot \psi_B = \sum_n \int_s \frac{M_p \cdot \bar{N}_i}{EJ} \cdot ds + \sum_n \int_s \frac{\bar{M}_i \cdot \Delta b \cdot dt}{h} \cdot ds + \sum_n \int_s \bar{N}_i \cdot dt \cdot t_0 \cdot ds - \sum_n \bar{R}_i \cdot \Delta$$

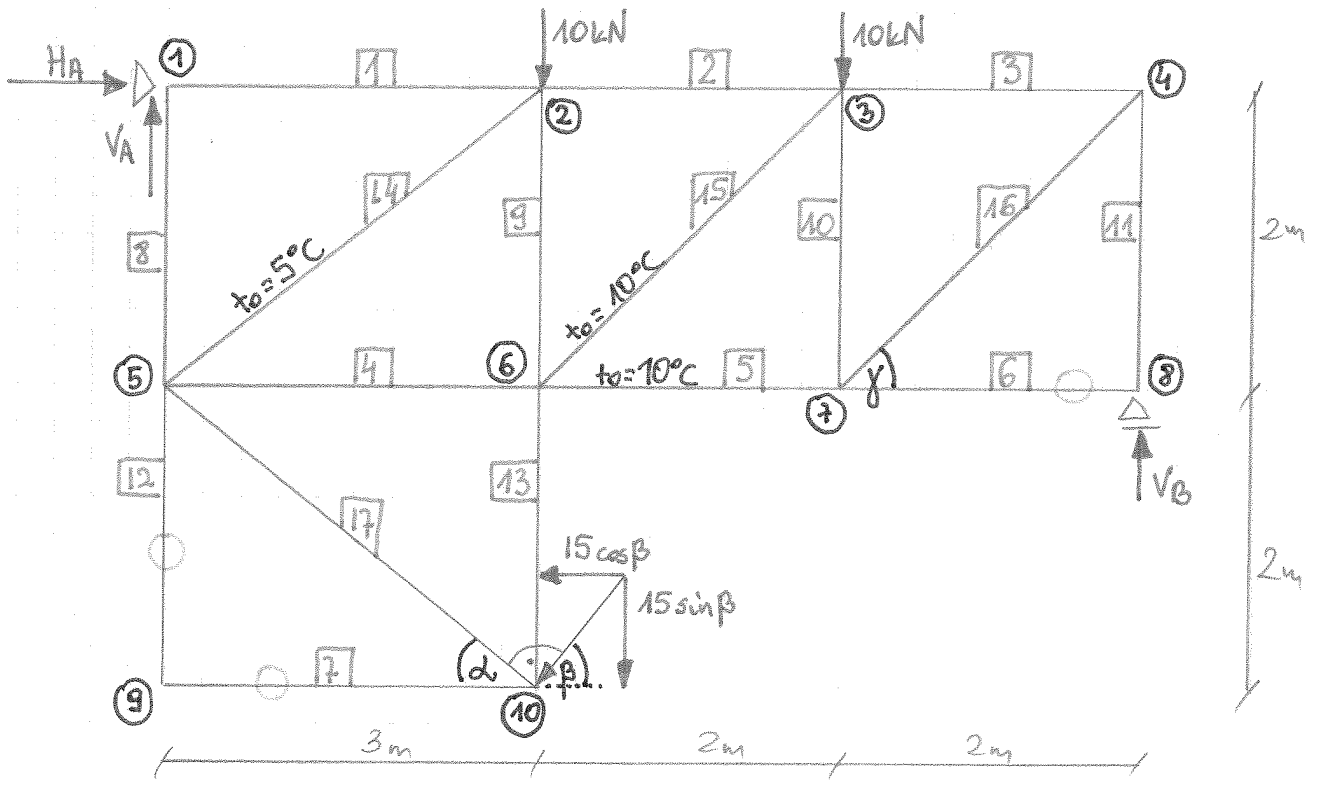
$$\eta = \frac{1}{2}$$

$$P \cdot \eta = \frac{1}{2} \cdot 2,5 \cdot \frac{1}{2} = 2,5 \text{ kNm}^2$$



$$\bar{1} \cdot \psi_B = \frac{2,5 \text{ kNm}^2}{2,1 \cdot 10^8 \frac{\text{kN}}{\text{m}^2} \cdot 45850 \cdot 10^{-8} \text{ m}^4} + 0 + 0 - \left(\frac{1}{2 \text{ m}} \right) 0,01 \text{ m}$$

$$\bar{1} \cdot \psi_B = -0,00474 \text{ [rad]}$$



STAN "P"

$$\sin \beta = 0,832$$

$$\cos \beta = 0,555$$

$$\sum X = 0 \quad H_A - 15 \cdot \cos \beta = 0 \quad \underline{H_A = 8,32 \text{ kN}}$$

$$\sum M_A = 0$$

$$10 \text{ kN} \cdot 3 \text{ m} + 10 \text{ kN} \cdot 5 \text{ m} - V_B \cdot 7 \text{ m} + 15 \cos \beta \cdot 4 \text{ m} + 15 \sin \beta \cdot 3 \text{ m} = 0$$

$$150,72 = V_B \cdot 7$$

$$\underline{V_B = 21,53 \text{ kN}}$$

$$\sum Y = 0$$

$$V_A - 10 \text{ kN} - 10 \text{ kN} - 15 \sin \beta + V_B = 0$$

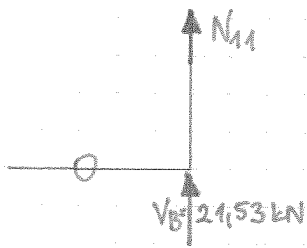
$$V_A + V_B = 32,48 \text{ kN}$$

$$V_A = 32,48 - 21,53$$

$$\underline{V_A = 10,95 \text{ kN}}$$

Soly wewnetrane i pniebrojach

sezet (8)

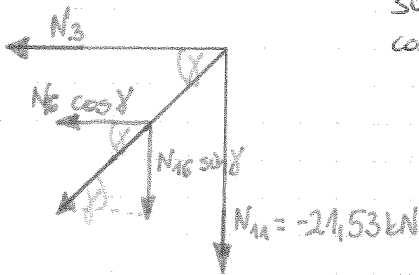


$$\sum Y = 0$$

$$N_{11} + 21,53 = 0$$

$$\underline{N_{11} = -21,53 \text{ kN}}$$

sezet (4)



$$\sin \gamma = 0,707$$

$$\cos \gamma = 0,707$$

$$\sum Y = 0$$

$$-N_{11} - N_{16} \sin \gamma = 0$$

$$21,53 = N_{16} \cdot 0,707$$

$$\underline{N_{16} = 30,45 \text{ kN}}$$

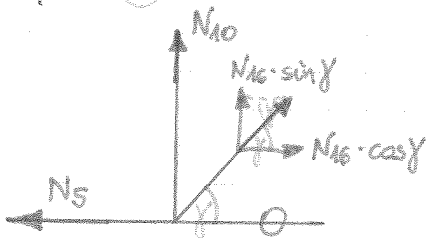
$$\sum X = 0$$

$$-N_3 - N_{16} \cdot \cos \gamma = 0$$

$$-30,45 \cdot 0,707 = N_3$$

$$\underline{N_3 = -21,53 \text{ kN}}$$

sezet (7)



$$\sum Y = 0$$

$$N_{10} + N_{16} \cdot \sin \gamma = 0$$

$$N_{10} = -30,45 \cdot 0,707$$

$$\underline{N_{10} = -21,53 \text{ kN}}$$

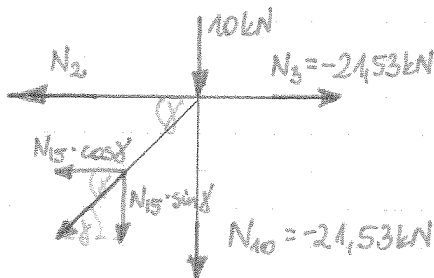
$$\sum X = 0$$

$$-N_5 + N_{16} \cdot \cos \gamma = 0$$

$$N_5 = 30,45 \cdot 0,707$$

$$\underline{N_5 = 21,53 \text{ kN}}$$

sezet (3)



$$\sum Y = 0$$

$$-10 - N_{10} - N_{15} \sin \gamma = 0$$

$$-10 + 21,53 = N_{15} \cdot 0,707$$

$$\underline{N_{15} = 16,31 \text{ kN}}$$

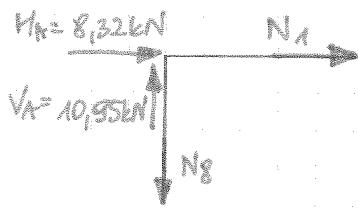
$$\sum X = 0$$

$$-N_2 + N_3 - N_{15} \cdot \cos \gamma = 0$$

$$-21,53 - 16,31 \cdot 0,707 = N_2$$

$$\underline{N_2 = -33,06}$$

szelvény ①



$$\sum X = 0$$

$$H_A + N_1 = 0$$

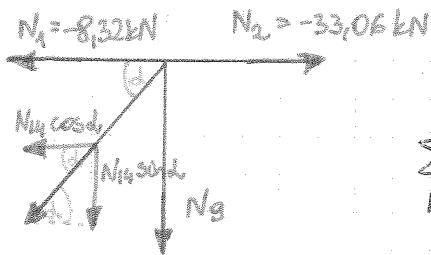
$$\underline{N_1 = -8,32 \text{ kN}}$$

$$\sum Y = 0$$

$$V_A - N_8 = 0$$

$$\underline{N_8 = 10,95 \text{ kN}}$$

szelvény ②



$$\sin \alpha = 0,555$$

$$\cos \alpha = 0,832$$

$$\sum X = 0$$

$$N_2 - N_1 - N_{14} \cos \alpha = 0$$

$$-33,06 + 8,32 = N_{14} \cdot 0,832$$

$$\underline{N_{14} = -29,73 \text{ kN}}$$

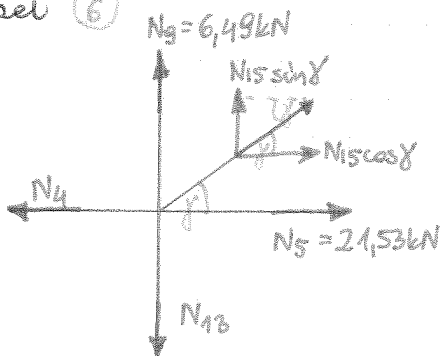
$$\sum Y = 0$$

$$-10 - N_{14} \cdot \sin \alpha - N_8 = 0$$

$$-10 + 29,73 \cdot 0,555 = N_8$$

$$\underline{N_8 = 6,49 \text{ kN}}$$

szelvény ⑥



$$\sin \gamma = 0,707$$

$$\cos \gamma = 0,707$$

$$\sum X = 0$$

$$-N_4 + N_{15} \cos \gamma + N_5 = 0$$

$$N_4 = 16,31 \cdot 0,707 + 21,53$$

$$\underline{N_4 = 33,06 \text{ kN}}$$

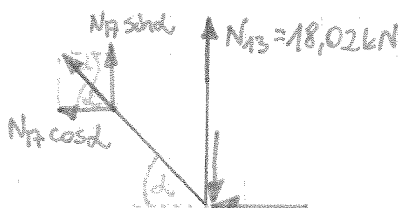
$$\sum Y = 0$$

$$N_8 + N_{15} \sin \gamma - N_{13} = 0$$

$$N_{13} = 6,49 + 16,31 \cdot 0,707$$

$$\underline{N_{13} = 18,02 \text{ kN}}$$

szelvény ⑩

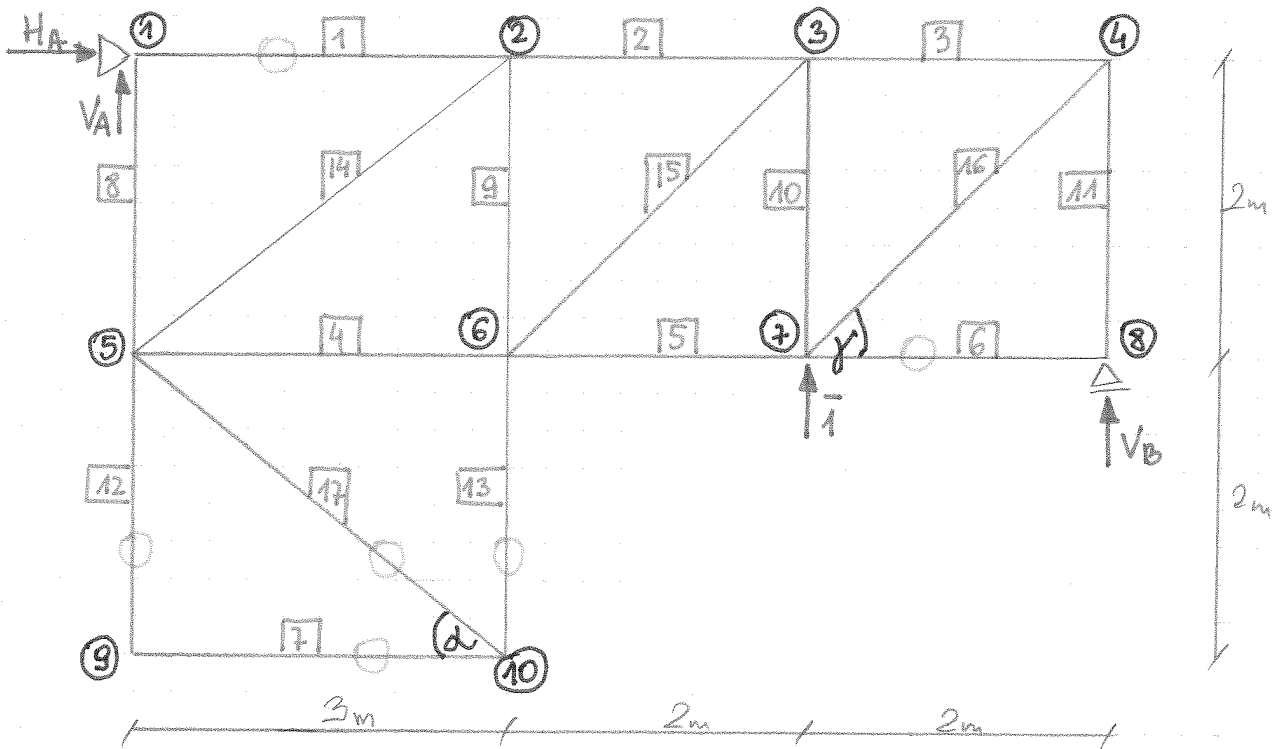


$$\sum X = 0$$

$$-N_{17} \cdot \cos \delta - 8,32 = 0$$

$$\underline{N_{17} = -10 \text{ kN}}$$

Діаграма переміщення в пункті 7 ΔY_7



СТАН "i"

$$\sum X = 0 \quad H_A = 0$$

$$\sum M_1 = 0 \quad -1 \cdot 5 - V_B \cdot 7 = 0$$

$$-5 = V_B \cdot 7$$

$$V_B = -0,714$$

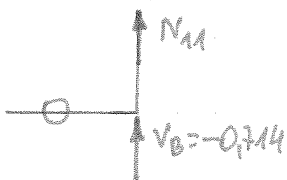
$$\sum Y = 0 \quad V_A + 1 + V_B = 0$$

$$V_A = -1 + 0,714$$

$$V_A = -0,286$$

Сили внутрішні в пунктах

вектор 8

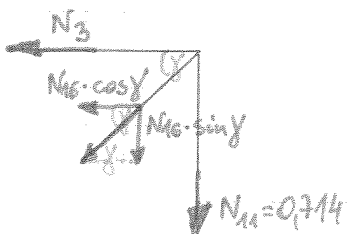


$$\sum Y = 0$$

$$N_{11} - V_B = 0$$

$$N_{11} = 0,714$$

вектор 4



$$\sin \gamma = 0,707$$

$$\cos \gamma = 0,707$$

$$\sum Y = 0$$

$$-N_{16} \cdot \sin \gamma - N_{11} = 0$$

$$-0,714 = N_{16} \cdot 0,707$$

$$N_{16} = -1,01$$

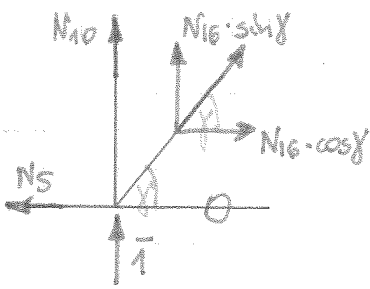
$$\sum X = 0$$

$$-N_3 - N_{16} \cdot \cos \gamma = 0$$

$$1,01 \cdot 0,707 = N_3$$

$$N_3 = 0,714$$

Δεξελί (7)



$$\sum X = 0$$

$$-N_5 + N_{16} \cdot \cos \gamma = 0$$

$$-1,01 \cdot 0,707 = N_5$$

$$\underline{N_5 = -0,714}$$

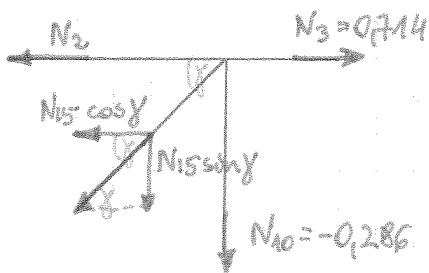
$$\sum Y = 0$$

$$N_{10} + N_{16} \sin \gamma + 1 = 0$$

$$N_{10} = 1,01 \cdot 0,707 - 1$$

$$\underline{N_{10} = -0,286}$$

Δεξελί (3)



$$\sum Y = 0$$

$$-N_{15} \sin \gamma - N_{10} = 0$$

$$0,286 = N_{15} \cdot 0,707$$

$$\underline{N_{15} = 0,404}$$

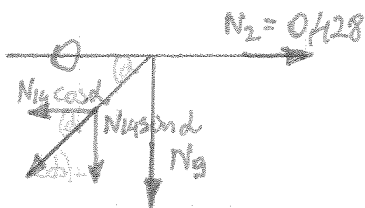
$$\sum X = 0$$

$$-N_2 + N_3 - N_{15} \cdot \cos \gamma = 0$$

$$0,714 - 0,404 \cdot 0,707 = N_2$$

$$\underline{N_2 = 0,428}$$

Δεξελί (2)



$$\sin \delta = 0,555$$

$$\cos \delta = 0,832$$

$$\sum X = 0$$

$$N_2 - N_{14} \cdot \cos \delta = 0$$

$$0,428 = N_{14} \cdot 0,832$$

$$\underline{N_{14} = 0,514}$$

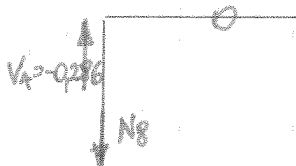
$$\sum Y = 0$$

$$-N_{14} \cdot \sin \delta - N_g = 0$$

$$-0,514 \cdot 0,555 = N_g$$

$$\underline{N_g = -0,286}$$

Δεξελί (1)

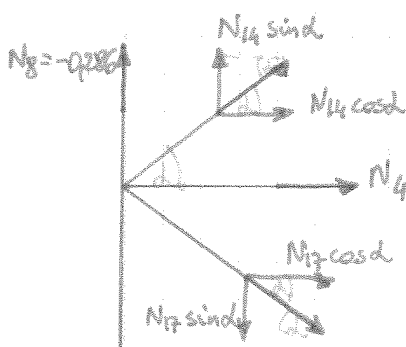


$$\sum Y = 0$$

$$-V_A - N_g = 0$$

$$\underline{N_g = -0,286}$$

Δεξελί (5)



$$\sum Y = 0$$

$$N_g + N_{14} \sin \delta - N_{17} \sin \delta = 0$$

$$0,286 - 0,514 \cdot 0,555 = N_{17} \cdot 0,555$$

$$\underline{N_{17} = 0}$$

$$\sum X = 0$$

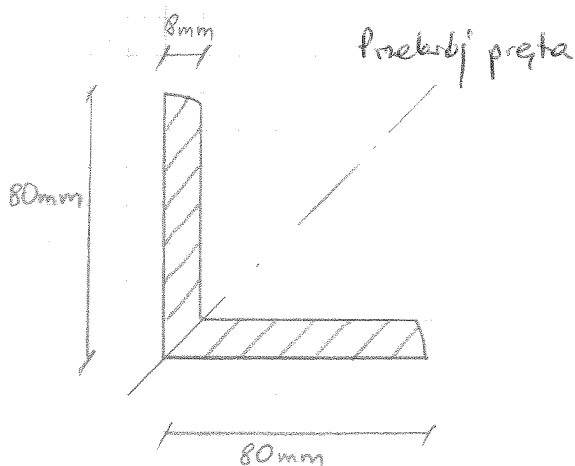
$$N_{14} \cdot \cos \delta + N_4 = 0$$

$$N_4 = -0,514 \cdot 0,832$$

$$\underline{N_4 = -0,428}$$

$N_{y \text{ preta}}$	L-dimenged preta [m]	$N_{y \text{ p}}''$ [kN]	$N_{y \text{ i}}''$	t_0 [K]	$\bar{N}_{y \text{ i}}'' \cdot N_{y \text{ p}}'' \cdot L$ [kNm]	$\bar{N}_{y \text{ i}}'' \cdot t_0 \cdot L$ [K·m]
1	3	-8,32	0	-	0	0
2	2	-33,06	0,428	-	-28,299	0
3	2	-21,53	0,714	-	-30,745	0
4	3	33,06	-0,428	-	-42,449	0
5	2	21,53	-0,714	10	-30,745	-14,28
6	2	0	0	-	0	0
7	3	0	0	-	0	0
8	2	10,95	-0,286	-	-6,263	0
9	2	6,49	-0,286	-	-3,712	0
10	2	-21,53	-0,286	-	12,315	0
11	2	-21,53	0,714	-	-30,745	0
12	2	0	0	-	0	0
13	2	18,02	0	-	0	0
14	3,606	-29,73	0,514	5	-55,104	9,267
15	2,828	16,31	0,404	10	18,634	11,425
16	2,828	30,45	-1,01	-	-86,974	0
17	3,606	-10,0	0	-	0	0

$$S_1 = -284,087 \text{ kNm} \quad S_2 = 6,412 \text{ Km}$$



$$A = 12,3 \text{ cm}^2 = 12,3 \cdot 10^{-4} \text{ m}^2$$

$$E = 2,1 \cdot 10^5 \text{ MPa} = 2,1 \cdot 10^8 \text{ kN/m}^2$$

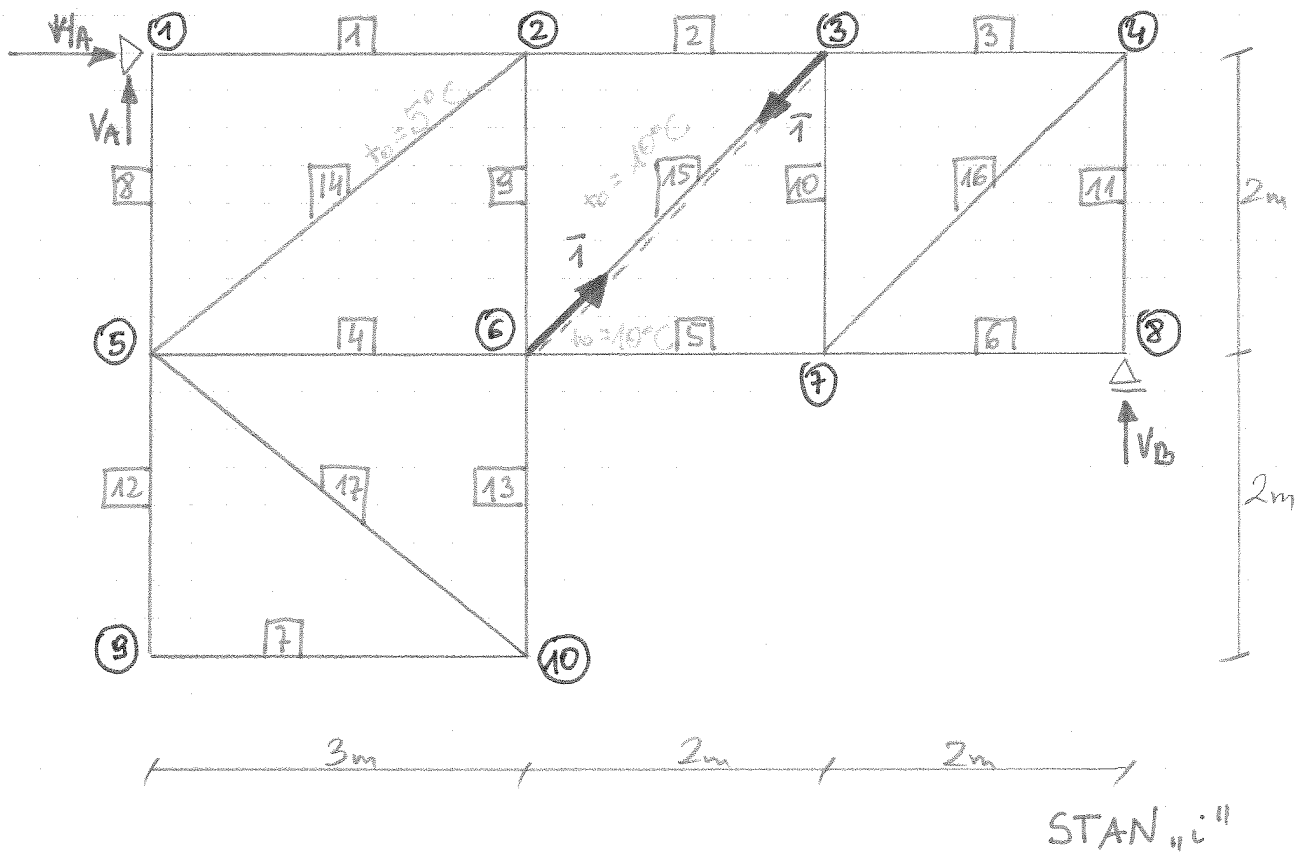
$$\alpha_t = 1,2 \cdot 10^{-5} \text{ 1/K}$$

$$\Delta Y_7 = \frac{S_1}{EA} + S_2 \cdot dt$$

$$\Delta Y_7 = \frac{-284,087 \text{ kNm}}{2,1 \cdot 10^8 \frac{\text{kN}}{\text{m}^2} \cdot 12,3 \cdot 10^{-4} \text{m}^2} + 6,412 \text{ Km} \cdot 1,2 \cdot 10^{-5} \text{ 1/K}$$

$$\underline{\underline{\Delta Y_7 = -0,00102 \text{ m}}}$$

Zmiana długości ΔL_{6-3}



$$\sum X = 0 \quad H_A = 0$$

$$\sum Y = 0 \quad V_A = 0$$

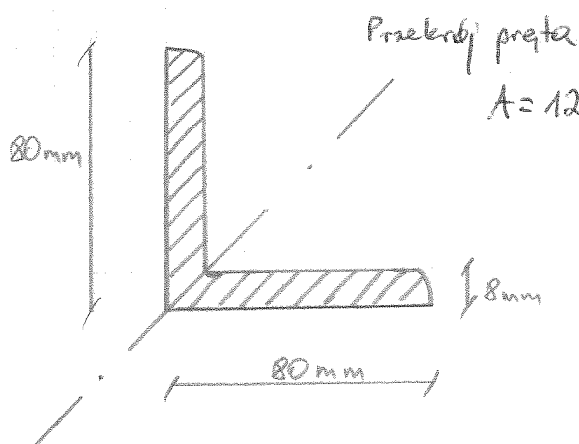
$$V_B = 0$$

pręt $N_{15} = -1$

pręty pozostałe - zerowe

Nr pręta	L-długość pręta	N_{up}	N_{ui}	t_0	$\bar{N}_{ui} \cdot N_{up} \cdot L$	$\bar{N}_{ui} \cdot t_0 \cdot l$
1	3	-8,32	0	—	0	0
2	2	-33,06	0	—	0	0
3	2	-21,53	0	—	0	0
4	3	33,06	0	—	0	0
5	2	21,53	0	10	0	0
6	2	0	0	—	0	0
7	3	0	0	—	0	0
8	2	10,95	0	—	0	0
9	2	6,49	0	—	0	0
10	2	-21,53	0	—	0	0
11	2	-21,53	0	—	0	0
12	2	0	0	—	0	0
13	2	18,02	0	—	0	0
14	3,606	-29,73	0	5	0	0
15	2,828	16,31	-1	10	-46,125	-28,28
16	2,828	30,45	0	—	0	0
17	3,606	-10,0	0	—	0	0

$$S_1 = -46,125 \text{ kNm} \quad S_2 = -28,28 \text{ Km}$$



Przekrój pręta

$$A = 12,3 \cdot 10^{-4} \text{ m}^2$$

$$E = 2,1 \cdot 10^8 \text{ kN/m}^2$$

$$dt = 1,2 \cdot 10^{-5} \text{ 1/K}$$

$$\Delta L_{6-3} = \frac{S_1}{E \cdot A} + S_2 \cdot \alpha \cdot L$$

$$\Delta L_{6-3} = \frac{-46,125 \text{ kNm}}{2,1 \cdot 10^8 \frac{\text{kN}}{\text{m}^2} \cdot 12,3 \cdot 10^{-4} \text{ m}^2} - 28,28 \text{ Km} \cdot 1,2 \cdot 10^{-5} \text{ 1/K}$$

$$\underline{\underline{\Delta L_{6-3} = -0,000518 \text{ m}}}$$